ISSN: 0976 – 2965
IJBET (2017), 6(2):13-17

# Novel approach to inverse problems for pre mature and infants' incubators

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ABSTRACT
In the world we are living today, human being faces a lot of health challenges, the challenges which may be caused by changing life styles and unhealthy eating among others, the changing habits results to several complicated health issues. Most developing countries experience higher infants' mortality rate as well as increased birth rate of pre mature babies while majority of the population don't have access to modern health care services due to expensive and unaffordable modern technologies. Changing life styles contributes to early age pregnancies as well as pre mature pregnancies. Pre mature babies are characterized by underweight, cold and severe dehydration in the first seven to ten days.
To save the lives of the pre mature infants whose susceptibility to severe suffocation due to cold and dehydration is high, neonatal intensive care is necessitated. Pre mature babies' incubators were introduced to save this purpose however these incubators are very expensive to most communities in the developing countries and due to this fact inadequate number of modern incubators are deployed while traditional methods rule the process.
Accuracy of measurements for infants' incubators have been challenging to most designers. In this paper we shall see a novel design approach which carters for inverse problems to infants' incubators for improved accuracy, and computerized temperature control, humidity, air ventilation and reduced alarm noises by noise free alert method using GSM modem implemented in PIC microcontroller.

**Key words**: pre mature babies, mortality rate, infants' incubator, skin permeability, inverse problems, GSM (Global System for Mobile Communication)

## INTRODUCTION

Inborn babies cannot control their body temperature instead they depend from their mothers' thermoregulation [1]. A baby born before the thirty sixth (36) week of pregnancy are said to be pre mature babies. Most pre mature babies are born on or before thirty first week of pregnancy, at this age premature babies are highly susceptible to risks of diseases, dehydration and cold [2].

Skin permeability of the infants born before the age of 31 weeks is higher, this will allow more water loss by the skin cells and hence dehydration [3]. To take control of this situation several parameters must be closely monitored, this includes humidity, and temperature controls. However air ventilation to the babies within an incubator must be taken care of. Despite the existing designs still Achilles heel on the accuracy of the parameters need improvement.

## LITERATURE REVIEW.

Infants incubators have long been in the market ever since 1860s, several advancements have been in place for years from temperature control, incubator bed turning, humidity control and air ventilation [4 ].
Current common advances have been the implementation of the premature babies' incubators with inclusion of the alarm system for any parameter beyond or below the preset limit to alert on possible machine malfunction state [5].

Accuracy of the temperature regulation inside the incubator has been a big challenge due to uneven distribution of the sensors and physician access to the infants through incubator windows and air ventilation mechanism. Due to this, temperature and humidity sensor network could not accurately sense temperature distribution inside an incubator [6].

Implementation of the alarm system has been a better achievement to the advances in the technology, Medical Doctors and other

ISSN: 0976 – 2965
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physicians could respond to whatever alarms heard from the incubator, However alarm systems have been found noisy in the hospitals and especially in the intensive care units [7].

Most infants' incubators have been designed to control humidity and temperature and fewer efforts were put to monitor respiration rate of the infants.

With this review we find that existing infants' incubators apart from other Achilles heel were out of control to monitor other important health parameters of the babies while inside the incubator[8],[9][10].

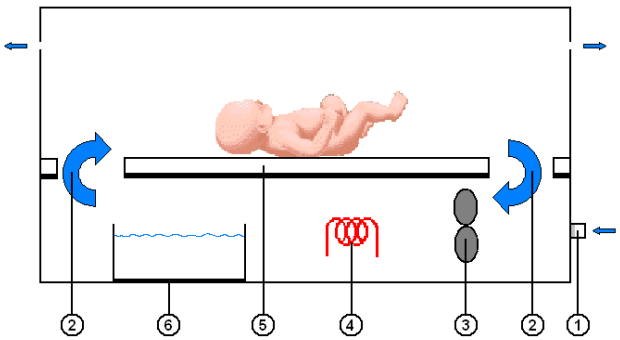
**METHODOLOGY**

*Temperature control:* Inside the incubator, temperature must be maintained at 36.9 ~37 $^{0}$ C. The incubator is designed in such a way that a preset value of temperature is set to provide required heating. However whenever there is change of temperature the control mechanism will either raise or lower temperature to the required level.

If the temperature is raised above the set value then the control system will command the fan to start and blow out higher temperature air particles. In controlling temperature, accuracy is highly eye marked in this research where several temperature sensors are positioned at different locations inside the enclosure and detection of each sensor would finalize to an average temperature inside the enclosure. As the heating element is positioned at one point, heat transfer inside the enclosure becomes questionable if temperature sensor network cannot sense equal temperature distribution in the system. Five sensors are set at the corners of the enclosure and one at the top middle position, the average temperature which is evaluated from each sensor gives the final temperature inside the enclosure. This approach increases accuracy of the temperature measurements in the infants' incubator.

$T_{av}=Avrg(t_1+t_2+t_3+t_4+t_5)$ Eqn .1

*Humidity control:* Like temperature control, relative air humidity is one of the important parameter to infants inside the incubator. Air humidity must be controlled at a pre-defined acceptable level, mostly




[1]air filter, [2]air circulation mode [4]heating element [3] fan/air blower [5] infants' bed.

Between 70% and 79% where 74~74.5% is the average relative humidity acceptable to infants. As it is with temperature sensors distribution inside the enclosure, similar approach is done with humidity sensors, to accurately collect relative humidity information from the incubator, four humidity sensors are fixed at the angles of the enclosure each, covering $90^{0}$.

*Digital display:* All the measured parameters are displayed at the incubator's display panel where users may set temperature and relative humidity values. The set values are constants to the control loop of the microcontroller firmware which takes control of all the operations of the incubator. The LCD display is deployed for this function.

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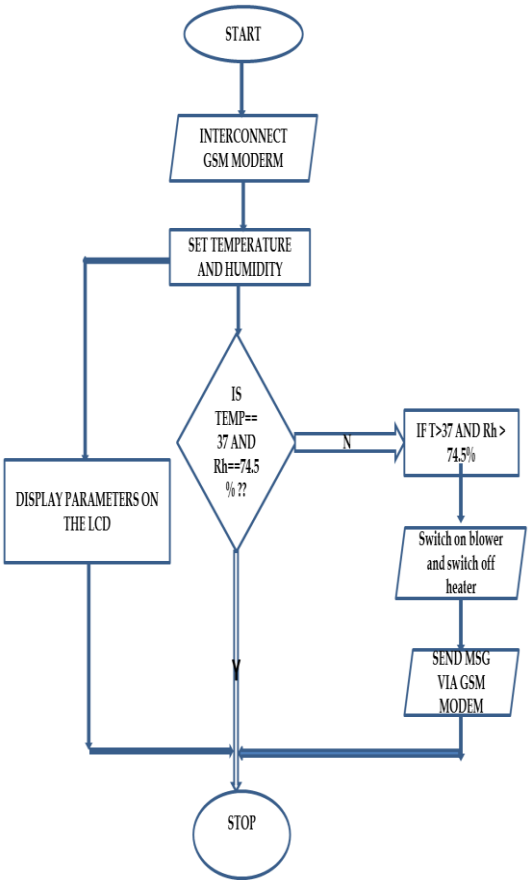


**SYSTEM OPERATION**

The above flow chart summarized operation of the controller firmware. Initially when the incubator is switched on, it will send Attention command through GSM modem to initialize communication between GSM devices with the incubator information. User may set temperature and relative humidity values at the control panel using keypads. Meanwhile this is done; temperature sensor and humidity sensors shall give input to the PIC microcontroller to initialize operation of the incubator. At every instant of time the control loop shall compare the input from the sensors with the predefined values set by the user and the controller makes decision based on the principle of operation [8].

**DATA ANALYSIS**

The main experimentation of the proposed system targets at ensuring accuracy of the measured data and hence operation of the system, this is in line with the approach used to include sensor network which give average measured values.

The performance of the system has improved and with the basis of the system operation, possible suffocation to the infants has been highly minimized. There is no more overheating to some parts of the enclosure, temperature and humidity distribution is nearly constant to every part inside the enclosure. The Achilles heels which were contributed by uneven temperature and humidity distribution has been minimized to the maximum.

Alarm noises which were caused by the system buzzer in previous systems has been eradicated instead LED indicators on the control panel indicates alarms using light and further alarm information forwarded to the system user through GSM modem interconnected to the controller. Excluding the buzzer will make the prenatal care unit free from noises. The relative

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IJBET (2017), 6(2):13-17

humidity finally averaged in the data acquisition loop is given by;

$Rh_{av}=avrg(Rh_1+ Rh_2+ Rh_3+ Rh_4)$ Eqn. 2

*Air ventilation and temperature control:* The incubator is fixed with a low powered DC fan/blower. When the temperature inside the incubator is higher than the pre-set value, the control system automatically switches on the fan to blow out hot air in exchange with cold air from outside. With this mechanism, the heater is switched off and maintained until when the temperature is below the set limit. The problem with this system is that, at this time air exchange is done irrespective of the impurities associated with the circulated air. Hence there are possibilities to airborne diseases to infants in case of possible cause or poor hygienic condition.

*GSM modem:* The previous infants' incubator used to ring an alarm when there is worse case of the changes of measurements inside the incubator. The alarm was found noisy and stubborn to infants and others in the postnatal care units. In this research project, the alarm system is integrated with GSM modem which will send data of the measured values to the selected mobile numbers through GSM system using attention commands in the PIC microcontroller. The user may respond to alerts sent without disturbing the baby inside the incubator. The worst case with previous alarms was that, physicians needed to stay closer to the incubator so that they may hear or visually see alarms.

**CHALLENGES AND FUTURE WORK.**

Apart from magnificent efficiency of the proposed system, there are some challenges encountered. With the air ventilation system, the system could only use available air in the room for exchange between the incubator and the surroundings.

The humidity control process makes use of the water container which remains uncovered and hence possible contaminations with other impurities.

The system is not integrated with the respiration monitor to monitor respiration rate of the infant babies inside the incubator.

The approach using GSM modem has been found the best but it has its own challenges, sometimes the user may be far from the phone or poor network coverage, the mobile phone may be; on silent mode or low battery, at this state users may fail to respond to alarms which need immediate reaction.

Therefore, the proposed system has highly minimized machine errors by improving system efficiency but has uncovered possible human errors contributed by attention to mobile phones.

For this system to measure many parameters automatically would need a number of components to be incorporated with, regardless of improved efficiency, including such components would add the cost of the system and hence developing countries could still fail to procure in large quantities.

In the future, designers would think of designing an incubator which can give information about many parameters of the infants inside the incubator, this is regardless of the cost but only looking at the efficiency of the system.

Infants cannot turn around by themselves at the bed; they need support after every couple of hours. In the future incubators can be designed with a turning mechanism to constantly distribute temperature and humidity over the body of the baby.

**CONCLUSION.**

It has a very interesting area of research which uncovers a number of challenges with pre mature babies in the postnatal units.

In this research however we have managed to design a low cost infants' incubator looking at the improved accuracy of measurement.

The Achilles heel contributed by uneven temperature distribution and humidity control within an incubator has largely been minimized.

ISSN: 0976 – 2965
IJBET (2017), 6(2):13-17

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